

APPENDIX O

DRAFT **PAPA Water Monitoring Plan**

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The management objectives for monitoring groundwater resources are to protect those resources from oil and gas operational impacts by determining if current mitigation measures are effective. Those objectives include:

- to protect and maintain existing livestock and domestic water wells and aquifers,
- to prevent excessive drawdown and inter-aquifer leakage of the Wasatch aquifer, and
- to protect and maintain groundwater discharge to streams.

A groundwater monitoring plan was developed by the PAPA Operators, BLM, WDEQ and others within the Pinedale Anticline Working Group (PAWG) as set forth as a condition of the PAPA ROD. It required an initial sampling of all stock and supply wells within 1 mile of the PAPA development and analysis for a mixed suite of inorganics and organics, and subsequent monitoring of water levels and reduced analyses. The number of wells being monitored grew rapidly to over 200 and it appears that the number will continue to escalate annually. WDEQ expressed concern to BLM in August 2005 that the groundwater monitoring program was flawed, particularly not discriminating monitored aquifers. Thus, the program is not satisfactory in some regards though it has grown tremendously. An overhaul is therefore proposed. The data already collected will be analyzed to form a baseline, but the monitoring is re-focused to efficiently achieve resource protection objectives. While the Wyoming State Engineer's Office records are not specific enough to identify individual aquifers, the Operators would make an attempt to correlate aquifers or at least show separation by listing the top and bottom of screened or perforated intervals relative to ground elevation and comparing zones used by industry versus those used for stock or domestic purposes.

The sampling protocol and analysis parameters currently used by the contractor (Sublette County Conservation District) as established by the PAWG Water Resources Task Group will be maintained unless altered by the PAWG process.

The Wasatch water supply wells used by the operators are completed in multiple Wasatch aquifers, and therefore, it is likely that monitoring a selected network of these wells will more reasonably represent the entire interval than attempting any selected aquifer monitor well or well nests. There is adequate water supply for domestic and livestock use above the Wasatch aquifers being used by the Operators. Therefore, it is important to monitor the intervals being used by the Operators to determine if any inter-aquifer leakage is occurring.

Objectives of groundwater monitoring are to establish baseline conditions and disclose any impacts to the resource. Components of the groundwater monitoring plan are:

- establish baseline conditions of water quality and quantity in alluvial and Wasatch aquifers;
- establish baseline conditions of water quality and quantity in PAPA groundwater discharge to surface water; and
- monitor any impacts to those baseline conditions.

Some potential impacts to groundwater resources are not of primary concern to the groundwater monitoring program, but are addressed by regulatory requirements and management practices. These include:

- Stormwater Pollution Prevention Plans (SWPPPs);
- Spill Prevention Countermeasure and Control Plans (SPCC Plans);
- Assurance of good annular seals in gas production wells through the Wasatch (WOGCC and BLM APDs)
- Assurance of good annular seals of water supply wells through shallow alluvium (WOGCC and BLM APDs).

This Groundwater Monitoring Plan does not address response plans that would be triggered by WDEQ regulation pertaining to a large spill, pit washout or other accident. Nor does it address evolution of monitoring to more closely follow any mitigation measures warranted by detection of deleterious impacts. Such events would initiate development of response and monitoring plans by the responsible parties and the jurisdictional agencies.

Groundwater monitoring would consist of measurement of well water levels to develop potentiometric data, and water parameters including pH and specific conductance (conductivity) as a surrogate for salinity. Any suspected impacts would be immediately reported to WDEQ as required in Chapter 4 Section 4 (a). The current sampling procedure would also require a re-sampling to determine the validity of the suspected impact. Some baseline data has been obtained which is adequate to characterize the major inorganic chemistry of PAPA groundwater.

Monitoring would be conducted on an annual basis by the Operators' contractor, and tabular and spatial results reported to PAWG, BLM and WDEQ before the subsequent monitoring season. This would allow agencies and the PAPA Operators to modify the monitoring schedule, if necessary, to answer any questions raised by the previous year's monitoring data. Monitoring data would be maintained by the PAPA Operators' contractor in a commonly available database. The Operators would be responsible for having a database constructed that would aid in the analysis of the data and for determining trends. BLM and WDEQ have reviewed this proposed groundwater monitoring program.

Alluvial Aquifer Monitoring (Mesa)

An old outwash alluvium covers part of the Mesa. It is a high permeability aquifer of good water quality that may be tapped by stock wells. Drilling supply wells do not tap into this aquifer, and are sealed through the shallow interval to prevent losses from this aquifer. Monitoring of this aquifer may also aid in watching for any possible contamination from surface spills or other releases of hydrocarbons or hazardous substances. The specific prevention plans for surface releases are listed above.

Monitoring water levels and conductivity in a number of these stock wells is intended to give a regional background against which any apparent impacts may be judged. This aquifer may be susceptible to drops in water level in drought periods due to both lack of recharge and higher demand.

The PAPA Operators, in coordination with BLM and WDEQ, would identify ten to twenty stock wells, widely distributed across the PAPA, in which water levels may be readily measured, and which static water levels may be easily and properly recorded. Survey data (N,E and elevation coordinates to 1 foot precision) would be provided for each of these wells.

Essential elements

10 stock wells

water levels and {T, pH, SC}

properly measure static water levels

Wasatch Aquifer Monitoring

The objective of monitoring groundwater in the Wasatch is primarily to manage the resource and to minimize regional impacts such as aquifer leakage. This is the principal drilling water supply aquifer.

The water supply wells drilled and completed by Operators would themselves become the monitoring wells for the Wasatch used to meet the objectives of Wasatch groundwater monitoring. These wells would be constructed in a manner allowing easy access for monitoring and sampling purposes. Proper construction and minimum standards of these Wasatch wells is under the jurisdiction of the Wyoming State Engineers Office.

For protection purposes, the Operators would adhere to the requirements from PAPA Record of Decision stating that “The Operators, in consultation with the BLM and State Engineers Office, will locate the production zone (perforated interval), for any water supply well within 1,000 feet of an existing stock or domestic well, at least 200 feet below that of the domestic well.” In addition, “The Operators, in conjunction with BLM and the State Engineers Office, will cement behind casing and/or seal off upper aquifers (up to 500 feet) in water zones that supply water for domestic or livestock proposes to prevent potential drainage/drawdown of that water supply and contamination from other aquifers.” (Page A-25, PAPA ROD).

The Operators, in coordination with BLM and WDEQ, would select 60 Wasatch wells to monitor, distributed over the PAPA, to serve as monitoring wells. Collar coordinates to 1 foot precision and completion details would be provided for each of these selected wells. Supply wells are, by and large, open across the major water bearing sand lenses of the Wasatch, and represent average properties of the variable sands at their locations. Very few of the Wasatch drilling source wells are logged. It is not known if correlation of aquifers is possible due to the laterally discontinuous nature of the sands. Logging may be conducted in selected cases to determine if correlation is possible.

Water levels and field parameters would be measured in at least 45 of these wells annually, it being understood that it may be inconvenient to get water levels in some wells on some occasions. It is in the Operators’ interest to obtain as full a baseline as possible.

Some supply wells, designated as monitor wells, would be actively pumping in any monitoring event. Where water levels are to be measured in active wells the pumping should be shut down for at least 4 hours to allow levels to recover, and at least two readings should be taken 5 minutes apart to demonstrate that they are reasonably stable. Care must be taken to properly assess well conditions to assure true static conditions are achieved prior to measurement.

Essential elements

98 Wasatch wells on roster

measure water levels and field parameters in at least 45 wells annually, may add wells as drilling proceeds into new areas

properly record static water levels

If adverse impacts to the Wasatch are observed, an alternate source could be deeper Fort Union aquifers combined with reuse of produced water where appropriate. Operators using Fort Union water should establish baseline data prior to extensive development of that aquifer.

Valley Fill Aquifer Monitoring

Valley fill is modern alluvium in watercourses, distinct from the older alluvial fan (terrace gravels on the northern part of the Mesa) deposits. Valley fill in tributaries to the rivers off of the anticline carry groundwater discharge to surface water. Valley fill groundwater has shallow seasonal and Wasatch groundwater discharge components; the former is subject to meteorological variability; the latter is potentially susceptible to depletion from groundwater extraction (drilling water supply wells). Only about 600 feet of Wasatch Formation is exposed from the top of the Mesa to the Green River valley floor. The current PAPA ROD requires that operators "...will locate the production zone (perforated interval), for any water supply well within 1,000 feet of an existing stock or domestic well, at least 200 feet below that of the domestic well". Also the PAPA ROD states operators "...will cement behind the casing and/or seal off the upper aquifers (up to 500 feet) in water zones that supply water for domestic or livestock purposes to prevent potential drainage/drawdown of that water supply and contamination from other aquifers." (Page A-25 PAPA ROD). These two protection measures will be continued in the SEIS to prevent Wasatch aquifer depletion. The objective of monitoring valley fill groundwater is to distinguish these components in baseline and assure that Wasatch discharge to surface water is not impacted or un-naturally reduced. Mitigation of reduced flows would consist of utilization of alternative (deeper) aquifers or reuse of produced water where appropriate.

The PAPA Operators, in coordination with the BLM and WDEQ, would install seven wells in the larger river tributaries draining the PAPA. These would be screened across the saturated valley fill deposits, from bedrock to a few feet above the water table. One of these would be located in the flood plain of the New Fork River to compare the river hydrographs with the local drainages; this would be located in the vicinity of one of the local tributary wells. The others would be located in tributaries, sufficiently above the rivers that their water levels will not be affected by river stage. These valley fill aquifer monitoring wells will also detect any contamination from surface spills from the oil and gas operations that might occur in the PAPA area and aid in preventing the contamination from reaching the perennial streams.

It is necessary to acquire monthly data from valley fill wells for 1 year to establish hydrographs with some continuity, for confident distinction of seasonal variability and baseflow components.

Essential elements

7 valley fill wells, one in the New Fork alluvium
measure water levels and field parameters monthly for one year to establish baseline
measure water levels seasonally thereafter

Domestic Well Monitoring

The PAPA Operators would continue to monitor domestic wells within 1 mile of existing or new gas wells in the PAPA. Some wells may be monitored less frequently where several wells are in close proximity and appear to be in the same aquifer.

Essential elements

40 wells on current roster
measure water levels and field parameters on wells depending on number of proximity wells in the say aquifer
properly record static water levels

Reporting

The PAPA Operators would maintain a database with well information, baseline chemistry data, and water level data.

The PAPA Operators would submit annual monitoring reports to PWAG Water Resources Task Group, BLM and WDEQ for as long as drilling is active. Reports would be issued each fall. Reports would contain an introduction identifying the reported monitoring period, the distribution list, a list of monitored wells and a summary of any impacts to groundwater resources observed. It would contain a well location map, hydrographs for all wells monitored in the reporting period and tables of field parameter readings. Other maps would be developed as needed to display the monitored data in a clear, comparative and concise manner. The Water Resources Task Group would forward any recommendations for plan alterations or procedural modifications to the PAWG at the annual review.